

Slave River Delta Ice Cover and Water Classification Using Machine Learning Techniques

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The Great Slave Lake (GSL) experiences seasonal variation in long-term temperature trends and ice phenology, which are influenced changes in Slave River inflow due to the factors such as climate change, upstream water management, and water extraction. The Slave River flows through Lake Athabasca and the Slave River Delta (SRD) before reaching GSL, bringing a rise in temperature that triggers the ice break-up process in the lake. Therefore, monitoring the SRD break-up processes and trend can serve as indicator of the overall break-up trend in GSL.

This research aims to develop a tool for mapping the SRD ice break-up processes, using machine learning (ML) techniques. Among ML methods, Random Forest (RF) has shown strong potential in lake ice mapping. To achieve this goal, a combination of satellite images with optical sensors at high spatial resolution, including Landsat-5, Landsat-8, Sentinel2a, and Sentinel2b, are used. The RF models were trained using manually selected training pixels to classify ice, open water, and cloud within the SRD. In addition to Landsat and Sentinel2 bands, two indexes, including the Water and Ice Classification Index (WICI) and a texture-based variable, the local average gradient of the red band, have been added to improve the models' performance. Testing with independent scenes shows accuracies of 90% and 97% for the Sentinel and Landsat models, respectively.

Break-up dates are identified based on the proportion of the ice versus water pixels in images with less than 20% cloud coverage. The break-up start period is defined by minimum and maximum thresholds of 60% and 90% on ice fraction. The values of thresholds are a trade-off between maximizing the number of available images and not including images acquired after the break-up period. The results show a statistically significant trend from 1984 to 2020 with a magnitude of 0.7 using the Mann-Kendall test and Sen's Slope estimator. These findings can inform policymakers and resource managers in making decisions that support the needs of northern communities in Canada.